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Education Improves Public Health and Promotes Health Equity

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Abstract

This article describes a framework and empirical evidence to support the argument that educational programs and policies are crucial public health interventions. Concepts of education and health are developed and linked, and we review a wide range of empirical studies to clarify pathways of linkage and explore implications. Basic educational expertise and skills, including fundamental knowledge, reasoning ability, emotional self-regulation, and interactional abilities, are critical components of health. Moreover, education is a fundamental social determinant of health – an upstream cause of health. Programs that close gaps in educational outcomes between low-income or racial and ethnic minority populations and higher-income or majority populations are needed to promote health equity. Public health policy makers, health practitioners and educators, and departments of health and education can collaborate to implement educational programs and policies for which systematic evidence indicates clear public health benefits.

Keywords

equity; disparities; social determinant; health in all policies

Education is a *process and a product*. From a societal perspective, the process of education (from the Latin, ducere, “to lead,” and e, “out from,” yield education, “a leading out”) intentionally engages the receptive capacities of children and others to imbue them with knowledge, skills of reasoning, values, socio-emotional awareness and control, and social interaction, so they can grow as engaged, productive, creative, and self-governing members of a society.[1] Of course, not all educational institutions achieve these goals for all children – far from it; educational institutions in the United States often fall short of goals, and too many students may be led into school failure, social dysfunction, and marginal living conditions with lifelong disadvantages.

Not all learning is acquired in a formal school setting. The *process* of education occurs at home, in school, and in the child’s community. Children in the United States spend a relatively small proportion of their waking hours in school – approximately 1,000 hours per year or about one fifth of their waking hours.[2] Thus there are many opportunities for

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informal education outside the school setting.[3] When researchers find evidence linking mental capacities, knowledge, feelings, and values with health outcomes,[4] not all consequences can be attributed to formal education.

As the product of the educational process, *an* education is the array of knowledge, skills, and capacities (ie, intellectual, socio-emotional, physical, productive, and interactive) acquired by a learner through formal and experiential learning. An education is an attribute of a person. And, although a person may be said to "have" a certain level of education at any particular moment, educational attainment is a dynamic, ever-evolving array of knowledge, skills, and capacities.

Although we conceive of education broadly, including both its formal and informal sources, the focus of our evidence review is the formal education that is measured in most research. Our recommendation also focuses on the formal education, from early childhood to college and beyond, that is, the subject of educational policy and, we argue, should also be the subject of public health policy.

In public health, researchers and practitioners have examined 3 principal relationships between education and health. First, *health is a prerequisite for education*: hungry children or children who cannot hear well, or who have chronic toothaches, eg, are hindered in their learning.[5] Second, *education about health* (ie, health education) occurs within schools and in many public health interventions; it is a central tool of public health.[6] Third, *physical education in schools* combines education about the importance of physical activity for health with promoting such activity.[7] Here we focus on 2 additional relationships between education and health. First, we propose that *education as a personal attribute is a central conceptual component and essential element of health*, similar to physical fitness. Second, we summarize the extensive literature demonstrating that formal *education is a contributing cause of health*.

We argue that education – the product and personal attribute acquired – is both a critical component of a person's health and a contributing cause of other elements of the person's concurrent and future health. Consistent with other definitions of health, a person who lacks basic elements of an education is not fully healthy.[8,9] For example, the 1978 Alma Ata International Conference on Primary Health Care defined "health" to include "a state of complete…mental and social well-being" – which we see as largely products of education. Attainment of a certain level of formal education by young adulthood affects lifelong health through multiple pathways.[8,10]

We then argue that, because it is both an essential component and a major contributing cause of health, educational achievement broadly should be a legitimate arena for public health intervention. Thus, public health practitioners could legitimately promote educational programs to advance public health. Education should also be recognized as an essential requirement for the disruption of the cycle of poverty and inequities in health. The public health community should expand research to better understand the causal relationships between education and health, and thereby identify evidence-based educational policies that have great potential to improve public health.

A Broad Concept of Education

We propose a broad concept of education as a personal attribute, which includes not only subject-matter knowledge, reasoning, and problem-solving skills, but also awareness of one's own emotions and those of others and control of one's emotions (ie, "emotional intelligence")[11] and associated abilities to interact effectively. "Education improves health because it increases effective agency, enhancing a sense of personal control that encourages and enables a healthy lifestyle. Education's beneficial effects are pervasive, cumulative, and self-amplifying, growing across the life course."[12]

In 1983, the National Commission on Excellence in Education's report, *A Nation at Risk*, launched a national conversation about the need for educational reform.[13] In 1990, the US Department of Labor initiated a program – the Secretary's Commission on Achieving Necessary Skills – to determine critical capacities for a US workforce to be provided by the educational system.[14] The capacities proposed were based on "a three-part foundation" reflecting the broad notion of education that we propose: Basic Skills (reading, writing, arithmetic, mathematics, listening, speaking), Thinking Skills (creative thinking, decision making, problem solving, seeing things in the mind's eye, knowing how to learn, reasoning), and Personal Qualities (responsibility, self-esteem, sociability, self-management, integrity/honesty). The project recommends as a central educational goal: "All American high school students must develop a new set of competencies and foundation skills if they are to enjoy a productive, full, and satisfying life."[14](p1) We would expand this list of outcomes to include a *healthy* life.

Education as an Element of Health

In our conception, basic education is an integral part of being healthy. A person is unhealthy if he or she lacks basic knowledge, the ability to reason, emotional capacities of self-awareness and emotional regulation, and skills of social interaction. These embodied personal attributes or mental capacities, the products of formal education as well as other learning experiences, are conceptually comparable to physical capacities of fitness and coordination – well-established components of health. "Education teaches a person to use his or her mind: Learning, thinking, reasoning, solving problems, and so on are mental exercises that may keep the central nervous system in shape the same way that physical exercise keeps the body in shape."[8](p738) A person is unhealthy who cannot conduct himself or herself effectively and achieve some level of "social well-being" – a critical element of the World Health Organization (WHO) conception of health, which recognized the contributions of social sectors beyond the health sector in promoting health.[9]

The projects of several US and international health agencies reflect this concept of education as a component of health. For example, the US Centers for Disease Control and Prevention recognizes "cognitive health" in its Healthy Aging Program; although the focus of this program is prevention and control of Alzheimer's disease, the "cognitive health" rubric suggests far broader considerations: "The public health community should embrace cognitive health as a priority, invest in its promotion, and enhance our ability to move scientific discoveries rapidly into public health practice."[15](p1) The National Institutes for

Health similarly has a “healthy brain” program that recognizes cognitive as well as emotional capacities as elements of health.[16]

Similar concepts are recognized internationally by the WHO, in accordance with its definition of health cited above. More recently, a WHO paper[17] included cognition and affect as 2 of 6 domains for the international comparison of *health status*.

Measures of Education as a Personal Attribute

Education is measured in a variety of ways. A common measure, years of schooling/educational attainment, is problematic insofar as time spent in school gives little indication of how the time is spent and what is learned.[2] School-level completion may be a better measure, but also varies in terms of the quality and quantity of what is learned. Standardized tests of subject-matter knowledge and reasoning skills may be still better for some purposes, but may offer challenges when compared across populations.[18]

Some[19,20] have argued that teacher-assigned grades are an alternate, if not better, predictor of long-term outcomes than standardized tests because they reflect not only academic achievement, but also classroom social and learning skills that indicate abilities to learn and to interact successfully. The breadth of skills addressed by this measure better reflects the broad concept of education argued here. Subjectivity, personal preferences, and comparability are challenges with teacher-assigned grades as a measure of achievement.

Evidence of Causal Association

It may seem odd that, in the perspective developed here, education – the product and the personal attribute – is at once an element of health and a cause of health. The relationship is similar to that of physical fitness and health. Fitness is an element of health and an important cause of subsequent health – not only of physical fitness, but of other facets of health as well, including cardiac health and mental health.[21–23] In addition to providing extensive evidence that education is associated with health, we argue that the underlying causal process is conceptually similar to the causal relationships between physical activity or an infectious agent and health. We provide some evidence of causation, noting that the notion of causal proof in a traditional deterministic sense has been challenged.[24]

Criteria to determine causality in public health developed by Sir Bradford-Hill in 1965[25] are still useful. They are:

- Strength of association linking hypothetical cause and outcome (as assessed, eg, by the magnitude of relative risks)
- Consistency of findings, eg, by different researchers in different settings
- Specificity – the connection of specific, narrow causes to specific outcomes
- Temporal sequence—the necessity of cause preceding consequence
- Dose–response relationship
- Plausibility in terms of current knowledge

- Coherence – similar to plausibility, the fit with other contemporary knowledge
- Experiment – offering the strongest support
- Analogy – the comparability of postulated causality with causality in similar phenomena

Most of the Bradford-Hill criteria clearly apply when linking education to health. An obvious exception is specificity, because education itself is a broad concept including many elements, and the causal consequences of education are also numerous and heterogeneous. Bradford-Hill did not regard specificity as essential, as in the case of cigarette smoke with its multiple health consequences. As Susser has argued, "Specificity enhances the plausibility of causal inference, but lack of specificity does not negate it."[26](p153)

The associations presented below satisfy several standard criteria for causation. At least 3 approaches are used: 1) observational cohort studies with concurrent controls, 2) natural quasi-experiments in education policy, and 3) educational experiments. In the sections that follow, we provide samples of evidence of the causal association between education and health, assessed first by various health-related outcomes: health risk and protective behaviors, wages and income (resources for health), self-assessed health, morbidity, mortality, and life expectancy. We then provide evidence from experimental studies. The literature on these topics is extensive[4,8] and here we describe only a few examples, from early childhood and beyond. Evidence of the association between measures of education – the personal attribute – and other health-related outcomes is positive, strong, and consistent.

Health Risk and Protective Behaviors Are Associated With Academic Achievement

Evidence of an association between high school student grades and risk behaviors in the United States is remarkably consistent; higher average grade achievement is associated with lower rates of risk behavior (Figure 1).[27] One plausible explanation is that there is causation in the reverse direction of what is proposed here, ie, that risk behavior interferes with academic achievement; such reverse causation seems reasonable, eg, for watching television and using alcohol. Also plausible is that other factors, such as strong values, promote both academic achievement and self-protective behaviors, or that academic achievement is associated with knowledge, which leads to risk avoidance. Another explanation is that underlying psychological or environmental conditions are associated with risk behavior and academic problems. Causation in both directions is likely. The consistency of a dose response for multiple behaviors is consistent with an effect of educational success on the avoidance of risky behavior.

There is also strong evidence of a dose response between years of education and many health-related risk and protective behaviors among US adults. Analysis of a representative survey of adults aged >25 years between 1990 and 2000 indicates that the prevalence of several risk behaviors is generally higher among those with fewer than nine years of formal education, begins to decline among those who have nine to 12 years of formal education, and continues to decline with additional years of education; this finding corresponds to the recognized importance of high school completion for subsequent health.[28,29]

Wages and Income, Resources for Health, Are Associated With Educational Success

Wages and income are not health outcomes, but are closely linked with health outcomes because they provide access to health-related resources, such as healthy food, a safe environment, and healthcare. A recent analysis[30] of trends in US wages over more than 20 years finds higher wages consistently associated with higher educational attainment and a trend toward increasing differences in wages by educational status. In the causal chain, high educational attainment is antecedent to high wages or income. A recent study[31] linking individual kindergarten standardized achievement tests with wages at ages 25–27 years indicates a remarkable linear association accounting for 17% of the variability in the wage outcome – 20 years later (Figure 2). Although high family income precedes and predicts educational success in children, controlling for such demographic characteristics of the kindergartner (including family income, household ownership, and marital status) diminishes, but by no means eliminates, the association found in this study.

Self-Assessed Health Is Associated With Educational Attainment

Self-assessed health is a well-established index of morbidity and predictor of mortality.[32,33] A recent study compares the association of educational attainment with self-assessed health in US and Canadian populations.[34,35] Controlling for basic demographics and income, those with less than a high school education in the United States are 2.4 times as likely as high school graduates and 4.1 times as likely as those with post-secondary education to rate their health as poor. Further adjusting these ratios for risk behaviors only moderately reduces the ratios, suggesting that education is related to self-reported health due to important factors in addition to risk behaviors.

It is plausible that health status affects the likelihood of educational achievement, but it is likely that the major force of causation is in the opposite direction. Not only is educational attainment closely associated with self-rated health, but the association increases with age when measured by the number of days per week reported as free of major symptoms. With increasing age, the gap in symptom-free days increases between those with a college degree, those with a high school degree or some college, and those with less than a high school degree, suggesting that the effects of education are pervasive throughout the lifespan, and that its consequences have cumulative effects on health over time.[36]

Morbidity is Associated With Educational Attainment

In the United States, although higher self-reported rates of several conditions, such as prostate cancer and sinusitis, are reported among more adults with greater levels of education, for most conditions the reverse direction of association is evident. Rates of major circulatory diseases, diabetes, liver disease, and several psychological symptoms (sadness, hopelessness, and worthlessness) show higher rates among adults with lower educational attainment.[35]

Mortality and Life Expectancy Are Associated With Educational Attainment

Evidence also exists of a strong association between educational attainment and mortality from many diseases.[37] The parallel relationship for three heterogeneous groups of illness or injury again suggests an underlying connection unrelated to the specific etiologic pathways

of each cause of death (Figure 3).[37] In addition, the modal age for completing formal education (the mid-20 s) substantially precedes the peak age for mortality in the United States (77 years of age) by many years, consistent with another Bradford-Hill principle, ie, the precedence of cause before effect.

From the perspective of life expectancy, at age 25 in 2005, a man in the United States with less than a high school education could expect to live an additional 44.2 years to age 69.2 years; a man with a graduate degree could expect to live more than 15 years longer. At age 25 years, a woman in the United States with less than a high school education could expect to live to age 74.9 years; a woman with a graduate degree could expect to live more than 11 years longer.[38]

Educational Experiments and Quasi-Experiments

True experiments in the field of education are uncommon. Nevertheless, several experiments have been conducted. Groups of children, often from low-income or minority families, have been exposed, sometimes with random assignment, to different forms of education and followed over time to determine long-term outcomes, including health-related outcomes, as shown in the following 3 examples of early childhood programs.

In the early 1960s, 3- and 4-year-olds with low IQs from low-income families were randomly assigned to either the High/Scope Perry Preschool Program – an educational program including home visits – or no intervention. Home visits were designed to strengthen parental engagement in the child's education. Participants were periodically assessed until age 40.[39] Over several follow-up assessments, intervention participants had greater levels of educational attainment, income, and health insurance, lived in safer family environments, and had lower rates of tobacco and drug use and risky driving behavior than controls. At age 40 years, however, more intervention than control participants had chronic diseases, but fewer intervention participants had died.

In 1972, healthy infants at risk of academic difficulties because of their demographic circumstances (eg, poor, minority, single parents) were randomly assigned to the Carolina Abecedarian Project or a control intervention (offered social services, nutritional supplements, and healthcare services, but no educational program).[40] The Abecedarian preschool program focused on developing cognitive, social, language, and motor skills from birth through age 5 years. Before entering kindergarten, control and experimental children were again randomized into either routine schooling or a strengthened school program complemented by home visits for parental guidance to reinforce child learning. At follow-up, both the preschool and the early schooling programs were shown to be beneficial in terms of academic achievement; the preschool program had the larger effect. By age 21 years, participants in the early childhood education intervention (combining those with and without the strengthened primary school programming) had better health behaviors and better health than those who did not receive the early childhood education intervention.[41] By their mid-30 s, those exposed to the intervention, particularly males, had substantially more favorable cardiovascular risk profiles than those exposed to the control condition.[42]

Finally, though not a true experiment, the Chicago Child-Parent Center program followed two groups of poor Chicago children aged 3 and 4 years: one exposed to an early childhood program and the other not exposed. Children residing in Chicago districts with federally funded kindergarten programs were eligible and selected on a "most-in-need basis"; comparison children lived in similarly poor neighborhoods with locally funded kindergarten programs. The Chicago Child-Parent Center provided educational enrichment from prekindergarten through the third grade, required parental involvement in the classroom a half-day per week, and provided nutrition and health services. At age 24 years, in comparison with control subjects, participants had lower rates of out-of-home placement (indicating child abuse), lower rates of arrests and conviction for violent behaviors, and lower rates of disability.[43]

A recent review of the effects of early childhood educational programs indicates that programs with strong instructional components and those evaluated with strong study designs have large and enduring effects on the educational, social, and health outcomes of participants.[44]

Several researchers have made use of natural quasi-experiments involving education policies that rapidly change years of schooling required, to evaluate the effects of the requirement on health-related and other outcomes. When state educational requirements change from 1 year to the next from 7 to 9 years, eg, cohorts of children of a certain age in that state will receive approximately 7 years of education, while their younger siblings will receive 9 years. The state where this policy is implemented may be compared by regression discontinuity analysis from before to after the change, but also with other states that have not made this change at the same time.

In one such study, Lleras-Muney[45] uses a sample of US census data to estimate the effects on mortality of changes in compulsory education requirements in 30 states, comparing birth cohorts before and after such changes between 1915 and 1939 with long-term follow-up data. Lleras-Muney concludes that each year of additional required schooling resulted in a reduction of mortality by 3.6% over 10 years, or gain of 1.7 years to life expectancy at 35 years of age. Although these data are old, it is likely that the general effects of increased educational requirements on mortality have not changed substantially. Other researchers have used regression discontinuity analysis to estimate the effects of education on rates of crime, arrest, and incarceration in the United States[46] and on teenage births in the United States and Norway.[47] Among researchers using this design, only Arendt[48] finds equivocal evidence regarding the effects of additional years of education on self-rated health, body mass index, and smoking in the United States, Canada, and Denmark. The heterogeneity of conditions affected by educational exposure again suggests a broad, nonspecific underlying "mechanism."

The Fallacy of the Endowment Hypothesis

Gottfredson has proposed that intelligence – innate intellectual and associated ability – rather than educational attainment is the "fundamental cause" of socioeconomic inequalities in health, a proposal referred to as the "endowment hypothesis."[49] Several basic features distinguish Gottfredson's notion of intelligence from the concept of education as defined in

this article: intelligence is regarded as “natural, not cultural,” “context-free,” and “highly heritable” – indicating a largely innate, biological foundation, little affected by environmental variability. From this vantage, education as conceived in this article may be regarded as largely determined by intelligence insofar as those with greater intelligence are both more likely to seek education and to succeed in acquiring it.

Gottfredson’s hypothesis is explicitly evaluated by others in a study of 2 US cohorts that assesses the contributions of education, income, and intelligence to 3 health outcomes: mortality, life-threatening illness, and self-rated health.[50] The researchers posit an alternative model, in which there are underlying “background influences on [socioeconomic status] and intelligence.” In this model, intelligence affects education and income, and both of these socioeconomic status characteristics in turn affect intelligence; a summary of research on this linkage[51] indicates that a year of education is associated with a gain of between 2 and 4 IQ points. In both study cohorts, intelligence during high school is measured by standardized and validated tests, the Henmon-Nelson test and the Wechsler Adult Intelligence Scale. The researchers find generally consistent evidence of pairwise dose–response associations between levels of education, income, and intelligence with each of 3 health outcomes.

The researchers then examine the questions: what is the effect of controlling the association of education and health outcomes for intelligence; of income and health outcomes controlling for intelligence; and of intelligence and health outcomes controlling for both education and income? This assessment allows answering 2 basic questions: how much does intelligence contribute to the effects of education and of income on health, ie, what are the effects of these determinants net the contribution of intelligence? And, to what extent are the effects of intelligence on health mediated by income and education? The researchers find that separately controlling the effects of education and income on health outcomes for intelligence alters the coefficients for education and income minimally and leaves all associations statistically significant at the 0.05 level or less, indicating that little of the effect of education on health is mediated by intelligence.

The effects of controlling the effects of intelligence on health for education and income are more complex. Only 1 of the 2 surveys finds a significant effect of intelligence on mortality ($P<.05$); controlling for education and income eliminates the significance of this finding. Thus, the effect of intelligence on mortality is largely mediated by income and education. Both surveys find statistically significant effects of intelligence for both life-threatening illnesses and self-rated health; however, the effect magnitudes are diminished by a mean of 69.4% and statistical significance is again eliminated for all findings except for self-rated health in one of the surveys. These findings indicate that the effects of intelligence on health outcomes are largely mediated by education and income.[50] There is thus substantial evidence that education has a strong effect on health, independent of background intelligence. Innate intelligence may be a “fundamental cause” principally insofar as it leads to higher education and income.

Causal Pathways and Evidence Linking Education and Health

Building on the work of others,[10,52] we constructed a model indicating the three major pathways linking education and health outcomes in adulthood and including the several facets of education – knowledge, problem solving, emotional awareness and self-regulation, values, and interactional skills (Figure 4). First is the psycho-social environment, including the individual's sense of control, social standing, and social support, which reflects and bolsters capacity and agency. Second is work, through which the individual may achieve satisfaction and income, which allows access to many health-related resources. Finally, healthy behavior may protect an individual against health risks and facilitate negotiation of the healthcare system.

Ross and Wu[8] used 2 national probability samples of US adults to assess the effects of completed education on self-perceived health and reported physical functioning. They first assessed the association between education and each of three broad covariate groups – psycho-social environment; work; and health knowledge, literacy, and behaviors – that are themselves determinants of health outcomes (Figure 4).[8] For each data source, they began with a model including as covariates only demographic characteristics of their samples. To the basic model, they first added employment and economic covariates, then social-psychological covariates, and finally risk behavior covariates, noting the changes in regression coefficients for educational exposures on health outcomes. This approach allowed assessment of the magnitude of each of these groups of covariates as pathways linking education to health-related outcomes. However, the relative contribution of each group of factors cannot be determined precisely, because these groups are unlikely to be causally independent, and covariate groups entered into the regression early are thus likely to show greater reductions in regression coefficients than those entered later.

In both samples, education was associated with all covariates in expected directions. The largest effect was for work-related variables, including income. Those with lower income not only had limited resources useful in maintaining health, but also may have experienced anxieties that exacerbate health problems. The effects of psycho-social resources were also statistically significant and of similar magnitude. Risk behavior and knowledge also contributed to the association between education and health by both measures. The 3 clusters of covariates together explain between 55% and 59% of the variance in self-reported health and between 46% and 71% of physical functioning in these surveys. This suggests that the smallest contribution to health outcomes is associated with health behaviors, which were entered last into the regression model. In both samples, education has a significant residual "direct" effect, independent of the three examined pathways. In summary, education's association with improved health is attributable to greater work opportunities and rewards, a greater sense of control and social support, healthier behaviors, and a direct effect on health. Similar results are found by Cutler and Lleras-Muney,[28] who use different sources to assess associations between educational attainment, health behaviors, and mortality in the United States and Great Britain.

In a separate study, Ross and Mirowsky[53] provide evidence that the effect of higher levels of education on health is mediated principally by its contents, including values and skills

imparted, and far less by means of status markers such as the diploma or the prestige of the degree-granting institution. Evidence for this conclusion derives from a regression analysis of national data including measures of years of education, receipt of diplomas, and school selectivity (based on test scores of entering freshmen). In another study, Reynolds and Ross[54] provide evidence that "the direct effect of education on well-being is greater than the direct effect of social origins, and the total effect of social origins is mediated mostly by education."[54](p226) Evidence derives from a regression analysis of two national data sources in which the researchers control for parental education, father's occupation, and childhood poverty. They also find that a person's level of education has a far greater effect on health if his or her parents were poorly educated than if they were well-educated. Unfortunately, in our society, parental and child educational levels are highly positively correlated, so that the children of parents with little education, who might benefit the most from higher levels of education, are least likely to receive that education.[55]

Ross and Mirowsky[55(pp597,598)] conclude (emphasis added): "…certain policy implications follow. *First, education policy is health policy.* Second, health policy must address the educational opportunities of children raised by poorly-educated parents. Otherwise those children, in adulthood, will suffer the multiplicative health consequences of low parental education and low personal education…Structural amplification condemns some families to the concentration of low education with poor health across generations…*Break that mediating link, and the moderating effect of higher education will suppress the health disadvantages of the socially disadvantaged origins.*"

High Societal Price in Health of Education Forgone

An estimate of the number of annual deaths attributable to lack of high school education among persons 25–64 years of age in the United States (237,410) exceeds the number of deaths attributed to cigarette smoking among persons 35–64 years of age (163,500) (Krueger et al., unpublished manuscript, 2013).[56] (The estimate of smoking-attributable mortality does not include adults younger than 35 years of age because mortality from smoking is negligible at this age.)

Several recent estimates have been made of economic costs to individuals, the government, and society of the failure of each American to achieve an optimal education. Although it may be argued that there is a moral duty to redress injustice and inequity regardless of cost, these estimates indicate the economic magnitude of this loss and the potential value of its redress.

Schoeni and colleagues[57,58] estimate the annual economic value of health forgone in the United States in 2006 by adults who lack a college education. For a population of 138 million aged 25 years or older with less than a college education, the economic value of the life and health forgone is US$1.02 trillion per year – 7.7% of US gross domestic product.

Levin and colleagues[59] provide an estimate of benefits to the government (in 2004 dollars) if those who did not finish high school had completed a high school education (or higher) with a diploma. Based on governmental benefits of income taxes associated with greater earnings of high school graduates and reduced costs of welfare and incarceration, Medicaid, and

lifetime savings of approximately US$40,000 per capita in public health expenses, they estimated a total lifetime benefit of US$209,000 for each high school dropout if he or she had instead completed high school. They then examined the costs and benefits of 5 programs with demonstrated efficacy in improving rates of high school completion. Cost–benefit ratios range from 1.5 to 3.5, indicating substantial governmental benefit.[59]

Education as a Domain of Public Health Action

Just as many areas of daily life are recognized domains of legitimate public health action – agriculture (eg, nutrition and food safety), transportation (eg, vehicle injuries, air pollution, and walking), immigration (eg, immigrant health and infection control), justice (eg, violent crime and prison health), urban design (eg, safety, walkable communities, and food deserts), and labor (eg, occupational safety and health) – so should education (beyond health education in schools) be recognized as a legitimate domain of public health action. Education is a critical component of health and, we argue, education is a major, long-term, multifaceted cause of health. In particular, education is a powerful means of breaking the cycle of poverty (which greatly affects ethnic and racial minority populations) and promoting health equity.(As this article was in press, the authors encountered an excellent paper by Cohen and Syme[60] which draws similar conclusions.)

Several federal agencies have supported "health in all policies,"[61] particularly through the National Prevention, Health Promotion and Public Health Council.[62] The US Department of Health and Human Services includes in its mission[63] to "engage multiple sectors to take actions to strengthen policies and improve practices that are driven by the best available evidence and knowledge" and in its overarching goals to "Create social and physical environments that promote good health for all."

States and the District of Columbia have also adopted a "health in all policies" perspective. California's "CAL Health in all Policies"[64–66] recognizes the potential for education as a means of moving toward health equity. "Promote efforts that demonstrate positive effects in closing the achievement gap. Collaborate on advancing strategies, addressing the major factors that inhibit the learning of all students." Counties (eg, Los Angeles, Baltimore) also have adopted a "health in all policies" perspective.[64,67,68]

The effort to pursue multi-sectoral strategies for health improvement is international, practiced in the European Union, Australia, and elsewhere. The European Union has adopted a social determinants-based approach: "Health in All Policies addresses the effects on health across all policies such as agriculture, education, the environment, fiscal policies, housing, and transport. It seeks to improve health and at the same time contribute to the well-being and the wealth of the nations through structures, mechanisms, and actions planned and managed mainly by sectors other than health."[69(pXVIII)]

In "A Framework for Public Health Action: The Health Impact Pyramid,"[71] Frieden writes, "Interventions that address social determinants of health have the greatest potential public health benefit" and contrasts social determinants – the base of the "health impact pyramid" – with higher strata in the pyramid. [70](p594) Among social determinants, education is fundamental, because education forms the new members of society – children and youth.

Effective teachers are facilitators of long-term health benefits. Beyond school health promotion, education as a means of public health intervention is more difficult to define, to administer, to measure, and to evaluate. It is cumulative, formative, and transformative, both for the individuals who experience it and for the society it recreates and modifies. Although these features make education more challenging than some other tools of public health, such challenges must not deter the public health community from working closely with the education community to investigate and understand this form of social determinant causation, evaluate the wide array of educational program types, and mobilize for action on this powerful force for public health benefits.

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Biographies

Robert A. Hahn received his PhD in anthropology at Harvard University (1976) and his MPH in epidemiology from the University of Washington (1986). Since 1986, he has served as an epidemiologist at the US Centers for Disease Control and Prevention (CDC) in Atlanta and is a member of the Senior Biomedical Research Service. He is the author of *Sickness and Healing: An Anthropological Perspective* (1995) and co-editor of *Anthropology and Public Health: Bridging Differences in Culture and Society* (2008), with a second edition recently published. In 1998–1999, he worked as a Capitol Hill Fellow in the US House of Representatives Committee on Veterans Affairs and in the office of Congresswoman Louise Slaughter. He is currently coordinating scientist of systematic reviews on health equity for the CDC *Guide to Community Preventive Services*.

Benedict I. Truman earned his BS in chemistry and MD from Howard University and his MPH from the Johns Hopkins Bloomberg School of Public Health, where he completed a residency in preventive medicine and public health and served as chief resident. He has held scientific and leadership positions in state, local, and federal public health agencies and is the associate director for science at the National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention at the US Centers for Disease Control and Prevention (CDC). In this role, he works with other scientists and program managers to ensure that the CDC's scientific products and research ethics meet the highest standards of quality and integrity. He has published many peer-reviewed journal articles on educational interventions for health equity; prevention and control of infectious diseases and chronic noninfectious diseases;

adolescent and school health; community preventive services guidelines; minority health and health disparities; employee performance and public health workforce development; and applied epidemiologic methods. He serves as the Consulting Editor for Infectious Diseases for the *Journal of Public Health Management and Practice*.

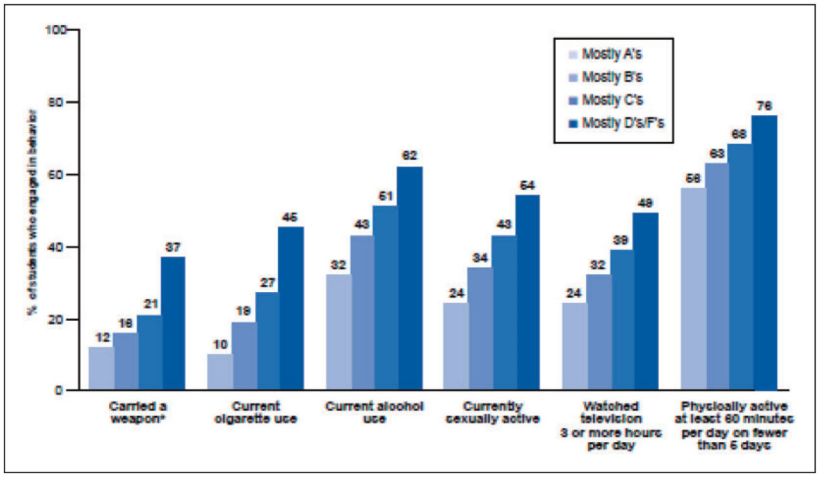

Figure 1.

Health-risk behaviors and school grades, United States, 2009.

Source: www.cdc.gov/healthyyouth/health_and_academics/pdf/health_risk_behaviors.pdf.

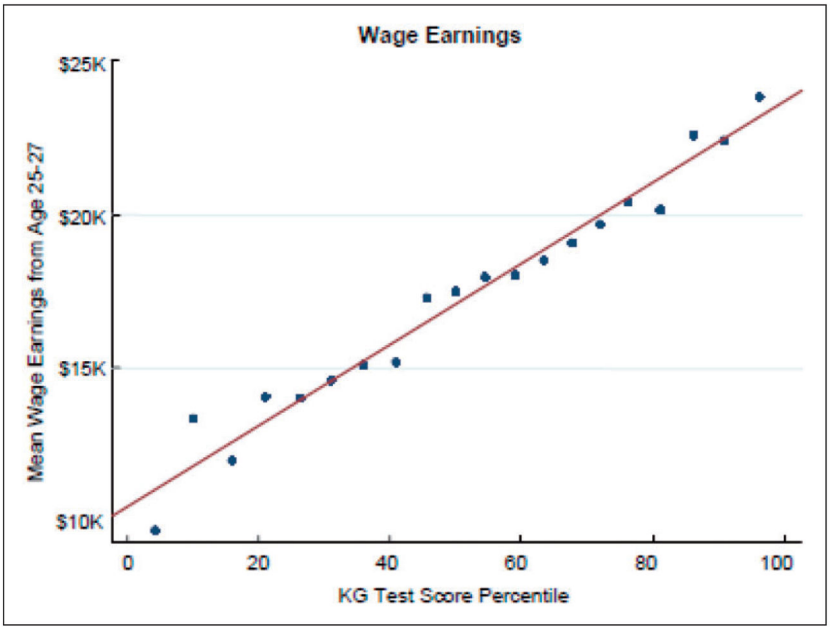

Figure 2.

Association between kindergarten test score percentiles and mean wage earnings, ages 25–27 years, Tennessee STAR program.

Source: Chetty, 2010.

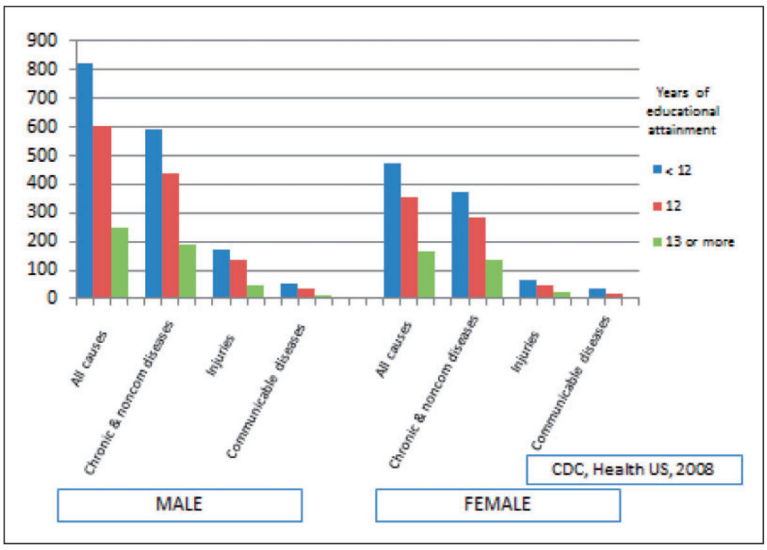

Figure 3.

Age-adjusted death rates among persons ages 25–64 years for several condition groupings, by sex and educational attainment. Selected US states, 1994–2005.

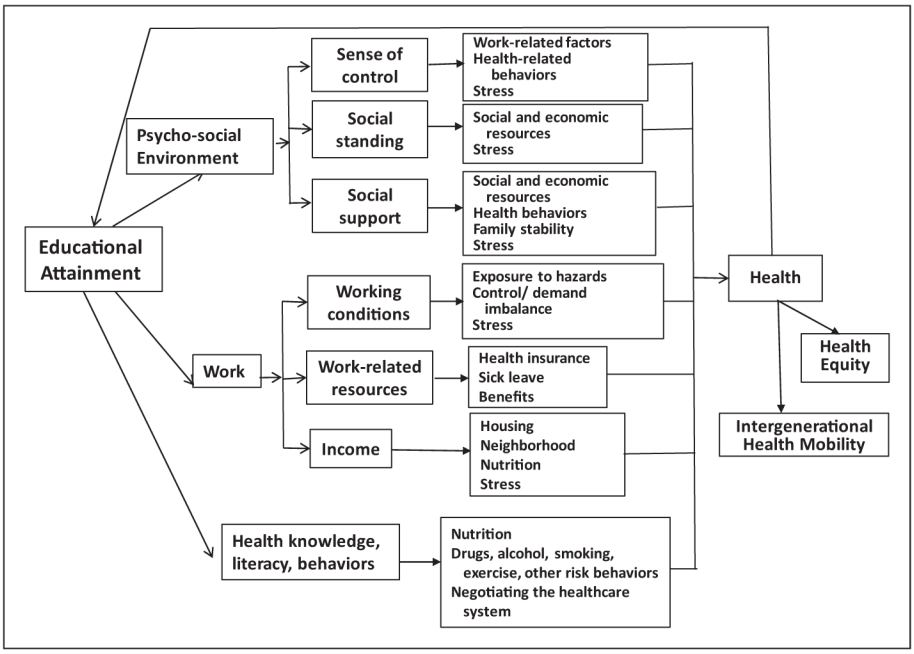

Figure 4.
Pathways from educational attainment to health outcomes.